TELEMEDICINE AND ADVANCED TECHNOLOGY RESEARCH CENTER MEDICAL LOGISTICS INTEGRATED RESEARCH TEAM

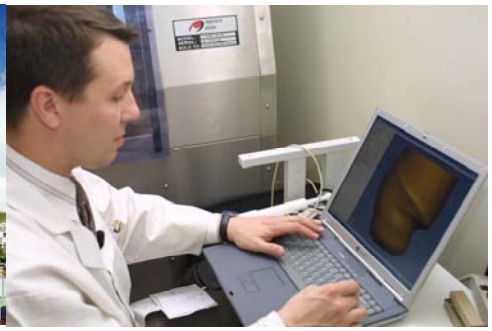
SEMINAR PROCEEDINGS, MAY 16–18, 2005

REPORT AR514T1

LMI
GOVERNMENT CONSULTING

AUGUST 2005





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Executive Summary

The Telemedicine and Advanced Technologies Research Center (TATRC) is a jointly staffed applied research organization whose mission is "to apply advanced technologies to deliver world-class healthcare to customers and providers, anytime, anywhere." Using the integrated research team (IRT) construct, TATRC regularly blends industry, academia, and military leaders to create synergistic successes in applied, clinically focused technology efforts.

The medical logistics technologies seminar is the first attempt to achieve similar synergies built on emerging technologies applied to the improvement of logistics performance. The event was cosponsored by TATRC, the Director of Medical Materiel at the Defense Supply Center, Philadelphia, and Penn State University's Center for Supply Chain Research. For 3 days, academic pioneers, military medical logisticians, and industry leaders met to study and evaluate research opportunities in four focus areas:

- Enterprise-wide integration of logistics technologies
- Use of these technologies to improve asset management and visibility
- Supply chain management processes and technologies
- Technologies with the potential to improve logistics supportability in the areas of energy, materials, transportation, and the environment.

The sponsors selected these focus areas because of their relation to known gaps in military capability, the potential for known or emerging technologies to address the gaps, and the potential to leverage existing military, industry, and academic efforts already underway.

The IRT process is a structured, closely facilitated method of addressing, documenting, and aggregating issues and opportunities across the breadth of technologies and processes represented in the four focus areas and the organizations and individuals who attended. Day One featured overviews of the IRT goals, logistics

issues, and organizations attending, with limited workgroup activity to more closely define the four focus areas. Day Two involved more detailed views of a broad range of logistics technologies that could potentially be integrated into the future medical logistics enterprise, and Day Three saw participants working to refine their thoughts into four separate roadmaps, which are integrated in this document into a single IRT roadmap (in draft form).

IRT participants evaluated the seminar at the end of Day Three. The evaluations indicated an interest in future seminars, most likely annually. The evaluations also indicated strong support for the inclusion of industry, academic, and military subject matter experts, although a number of participants suggested that more time for questions and answers, more panel-type discussions, and more military background briefings on the Defense Medical Logistics Standard Support program, current operations, and the overall medical logistics domain would be useful. Participants also suggested that clearer descriptions of the desired outcomes and more read-ahead material would be helpful. Planning for future medical logistics IRT activities will consider these suggestions.

The seminar resulted in the creation of a draft roadmap for establishing priorities, estimating time and resource requirements, and assessing the viability of technologies in an operational context. Top priority was assigned to the following technologies:

- Enterprise solutions needed to provide end-to-end supply chain integration and operation.
- Enhanced modeling and simulation tools to improve planning for wartime medical logistics support.
- Radio-frequency identification technology (RFID) and other automatic identification technologies.
- Point-of-use technologies.
- Medical product improvements to simplify, reduce, or eliminate cold chain, waste stream, power, and other logistics support requirements.

Through the Medical Logistics Proponent Subcommittee (MLPS), joint medical logistics leaders will use the roadmap to guide future research efforts.

The IRT also produced a clear agreement that TATRC should function as the research and development (R&D) element of the joint medical logistics community. Joint governance of TATRC's R&D efforts by the MLPS will provide optimal integration of research priorities and outcomes with the overall vision and strategy of the joint medical logistics community. Charters and other governance documentation may require modification to enable this, but the overall outcome will be a functionally-steered, coordinated strategy enabling flexibility, effectiveness, and relevance.

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Introduction

BACKGROUND

The Telemedicine and Advanced Technologies Research Center (TATRC) is a jointly staffed applied research organization whose mission is "to apply advanced technologies to deliver world-class health care to customers and providers, anytime, anywhere." Using the integrated research team (IRT) construct, TATRC regularly blends industry, academia, and military leaders to create synergistic successes in applied, clinically focused technology efforts.

SEMINAR

The medical logistics technologies seminar described in this report is the first attempt to achieve similar synergies built on emerging technologies applied to the improvement of logistics performance. The event was cosponsored by TATRC, the Director of Medical Materiel at the Defense Supply Center, Philadelphia (DSCP), and Penn State University's Center for Supply Chain Research. For 3 days, academic pioneers, military medical logisticians, and industry leaders met to study and evaluate research opportunities in four focus areas and their underlying major topics:

- Enterprise-wide integration of logistics technologies
  - Collaboration throughout the logistics network
  - Enterprise resiliency and security
  - Enterprise responsiveness and flexibility
  - Interconnectivity across the military services
  - Interconnectivity with the U.S. Transportation Command (USTRANSCOM), intergovernmental agencies, industry partners, and other enterprises
- Use of these technologies to improve asset management and visibility
  - Application of enabling technologies for asset management, including radio frequency identification (RFID), wireless and handheld, and global positioning technologies

- Sense-and-respond logistics for asset diagnostics and prognostics
- Processes and applications at specific nodes in the supply chain
- Clinical user interfaces with the supply chain

- Supply chain management processes and technologies
  - End-to-end supply chain visibility
  - Application of enabling technologies for supply chain management
  - Supply chain segmentation and criticalities
  - Transportation utilization, capacity, and choke points, including distribution functions
  - Supply chain planning and dynamic adaptation

- Technologies with the potential to improve logistics supportability in the areas of energy, materials, transportation, and the environment.

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IRT participants evaluated the seminar at the end of Day Three. The evaluations indicated an interest in future seminars, most likely annually. The evaluations also indicated strong support for the inclusion of industry, academic, and military subject matter experts, although a number of participants suggested that more time for questions and answers, more panel-type discussions, and more military background briefings on the Defense Medical Logistics Standard Support (DMLSS) program, current operations, and the overall medical logistics domain would be useful. Participants also suggested that clearer descriptions of the desired outcomes and more read-ahead material would be helpful. Planning for future medical logistics IRT activities will consider these suggestions.

The seminar resulted in the creation of a draft roadmap for establishing priorities, estimating time and resource requirements, and assessing the viability of technologies in an operational context.

REPORT ORGANIZATION

The remainder of this report is organized as follows:

- Chapter 2 discusses Day One of the seminar, which featured introductions and presentations on the future medical logistics enterprise, army distribution process, supply chain visibility, supply chain 2020, future trends in logistics technology, mobile computing and Battlefield Medical Information System–Telemedicine (BMIST), and other emerging technologies. The day closed with the formation of workgroups.

- Chapter 3 discusses Day Two of the seminar, which featured presentations on DoD medical logistics in 2005, Dell practices, RFID, the emerging complexity in supply chain management, point-of-sale technology in medical logistics, cold chain management, and advances in technology in miniaturization, energy research, waste stream management, and oxygen and water production. The day closed with a panel discussion.

- Chapter 4 discusses Day Three of the seminar, which featured breakout group sessions that discussed the four focus areas and produced input for the consolidated medical logistics technology roadmap. The seminar concluded on Day Three, having made immense progress in describing, assessing, and prioritizing many technologies, business processes, and organizational activities and beginning plans for another seminar.

- The appendixes provide supporting information.

Chapter 2
Seminar Day One

INTRODUCTION

Mr. Jim Olson, Chief of Staff, TATRC, welcomed the IRT participants, noting that this particular IRT is "a dream come true" for TATRC and its staff—a new opportunity for the ongoing development of the medical logistics community. Mr. Olson introduced Colonel James Romano, Acting Commander, U.S. Army Medical Research and Materiel Command (MRMC), retired Brigadier General Rich Ursone, and retired Brigadier General Mack Hill, as well as other distinguished guests and participants.

He challenged participants to make the next 3 days the most worthwhile, creative, and promising meeting possible, viewing it as an opportunity to define the future of military medical logistics. Mr. Olson noted that all of the participants are busy individuals with tremendous time constraints, but also observed that the meeting was a 3-day opportunity to form new alliances and contacts. He concluded with a short video highlighting potential uses of advanced technology in the military health system.

Mr. Conrad Clyburn, Special Assistant to the Director, TATRC, commented that "amateurs talk about tactics, but professionals talk logistics" as an introduction to the next 3 days. He summarized MRMC's mission, which consists of four major functions: medical research, development, and acquisition; medical logistics; medical information management/information technology (IM/IT); and medical facilities. He also summarized the core research interests of MRMC and highlighted TATRC's place in the MRMC organizational structure.

TATRC's mission—improving military medicine through the application of advanced technologies—includes $198 million in annual funding from a variety of sources, including $171 million in congressional special interest funding. Operational capabilities at TATRC include joint medical readiness, battlespace medical awareness, and the effective employment of medical forces. TATRC programs are managed through the inputs, controls, mechanisms, execution, and outputs process, which ensures effective oversight and control of research efforts.

Mr. Clyburn noted that TATRC is a network of "best-of-breed" public and private advanced medical technology partnerships, intended to reap benefits for military medicine, and includes basic research, applied research, demonstration and validation, and engineering, manufacturing, and development.

Mr. John DePasquale of TATRC remarked on the structure and content of the medical logistics IRT. He expressed his regret that not everyone in the room was scheduled to present since each participant had great value to add, and the IRT as a whole would benefit from all possible input. He described the challenges—better viewed as opportunities—that faced the group. Mr. DePasquale also noted that the genesis of this IRT was actually rooted in discussions of a year ago, when medical logistics and technology leaders recognized an opportunity to leverage emerging and advanced technologies to improve medical logistics support to clinicians, patients, and others depending on this community in peace and war.

Remarks By Acting Commander, MRMC

Colonel James Romano, Acting Commander, MRMC, established the framework for the 3 days to follow and welcomed all participants, including Brigadier Generals Ursone and Hill.

He offered a parable about his encounters with the medical logistics system early in his career. His encounter as a customer taught him both the difficulty of learning the intricacies of a complex supply system and the need for simplifying and streamlining such systems to make them optimally useful to customers. COL Romano also stressed the need for reliability in customer support, for continuous feedback to customers, and for exploring new ways of providing logistics support in future battle scenarios.

He emphasized the fluid nature of the modern battlefield, changing technical challenges of supporting it, and dynamics of battlefield medicine in such an environment. The shifting sands of modern warfare pose special challenges to logisticians, whose success depends on the ability to accurately and rapidly predict logistics needs despite operational uncertainty. COL Romano noted that the definition of a logistician's ultimate customer has now broadened to encompass warfighters, their families, and, finally, the American public, which demands superior logistics support to ensure the health and welfare of its military.

Technology will dramatically change the way warfare is conducted and will transform the way military medicine supports a warfighter. It must therefore transform logistics as the future becomes clearer. The future medical logistics system will require tailored, customized support to individual warfighters, precise in its delivery modes and responsive in its timing. Developments of the past decade—greatly increased use of commercial capability, commercial off-the-shelf (COTS) products, and just-in-time delivery methods—are only a precursor to the changes to come. These changes will make use of emerging technology, but will be premised on changes in business practices, processes, and philosophy.

Remarks By Dr. Curley, Chief Scientist, TATRC

Dr. Kenneth Curley summarized the IRT process and its intended outcomes. The overriding goal was to develop a 5-year research and development roadmap, prioritized according to relevance, including estimates of funding requirements, where feasible. A facilitated process of plenary sessions would disseminate information, and workgroups—multidisciplinary, self-determining, and schedule-focused—would develop the roadmap.

Intergroup communication was possible although participants were asked to focus their attention on their assigned group to prevent "knowledge gaps" or disconnects. Dr. Curley reminded the participants that their concepts should support the military medical environment, which requires technologies that are modular, light, mobile, fault-tolerant, teleoperable where possible, and based on an open architecture.

FUTURE MEDICAL LOGISTICS ENTERPRISE

Mr. Butch Hammel of the DMLSS Program Office outlined the program and its future direction on behalf of Colonel Kathy Erickson, Program Manager. Mr. Hammel observed that many of the goals envisioned for DMLSS during its early development have now been achieved, and new and visionary goals for the future are now being formulated. Goals formulated during the 1990s encompassed improved use of the commercial supply chain, greater integration of the medical logistics community, enhanced use of e-commerce tools, improved efficiency through inventory reduction, use of just-in-time resupply concepts, and system interoperability.

Now that DMLSS has created a mature family of medical logistics applications to support the community, focus is shifting to new goals, which may include increased focus on business intelligence tools, such as the Joint Medical Asset Repository (JMAR), implementation of decision support tools, such as the JMAR Executive Dashboard, and exploration of other technologies. As medical logistics is reengineered for the year 2020, principles such as speed, rapid adaptation, and improved linkage within the healthcare delivery system will serve as guidelines. The new "sense-and-respond" capability, linked to awareness of clinical needs, provides a context for developing new, network-centric concepts that predict, anticipate, and coordinate logistics actions for end-to-end—point-of-care to source-of-support—logistics management. Logistics functions are intrinsically linked to core healthcare functions, but require much greater integration at the process and systems level to optimize support to the latter.

Mr. Hammel also summarized the DMLSS transformation initiative—known as Joint, Enterprise-Wide Logistics–Medical (JEWL-M)—a fundamental shift in DMLSS architecture, functions, and technology. The medical logistics leadership intends to reach JEWL-M transformation objectives by creating a hybrid system

of DMLSS functionality to support hospital logistics integrated with a COTS enterprise resource planning (ERP) system to support the enterprise. JEWL-M will also provide an open platform for the integration of additional enabling technologies, such as those being reviewed in this IRT. Mr. Hammel closed by encouraging participants to think creatively, challenge convention, and find ways to apply the very latest technologies to the medical logistics domain.

ARMY DISTRIBUTION PROCESS

Dr. John Halliday, PhD, of Rand Corporation, summarized the Army's recent completion of a "define-measure-implement" process to create dramatic improvements in the cumbersome Army distribution process. He also noted, though, that the improvements applied to peacetime processes in the continental United States (CONUS) have not yet been fully applied to the transition-to-war or in-theater distribution processes. The joint supply chain vision now being implemented should better align organizations and processes to support wartime distribution needs. Dr. Halliday also described difficulties that surfaced in Army operations during Operation Iraqi Freedom and the steps taken to remedy them, including optimizing distribution practices for materiel moving to the theater.

SUPPLY CHAIN VISIBILITY

Ms. Ann Grackin, Chief Executive Officer of ChainLink Research, Inc., summarized her firm's activities in support of the defense logistics function. ChainLink is a research, education, and advisory company working with policy, process, performance, and enablers to help improve the operation of the military supply chain. She summarized the transition from vertical to virtual supply chains and highlighted future needs to create a "federated" supply chain based on extended enterprises of supply chain partners. Federated supply chains will employ market-driven, fast-flowing, global network management and increasingly use technological enablers.

Two emerging, converging technological forces apply to this concept:

- Pervasive computing technology, which creates a ubiquitous, secure, highly integrated wireless network more powerful and less expensive than anything previously seen

- Integrated supply chain management systems based on network-centric architectures, such as those offered by global logistics enterprises that now support third-party customers as application services providers.

This convergence produces a capability now referred to as the "intelligent network"—net-hosted, net-centric capabilities that offer enterprise-level benefits to organizations without the means or need to design their own enterprise systems. This new world is based on new constructs such as peer-to-peer, people-to-people

connectivity, semantic alignment of activities on the basis of function, and an "event architecture" based on a publish/subscribe model of data access. For the medical logistics community, the use of RFID and other technologies will change distribution processes and other functions.

Ms. Grackin also described an integrated medical-grade network, which will eventually integrate patient, medical procedure, and medical logistics data. Systems capable of "multidimensional management"—through enterprise-level, single-instance computing solutions that fuse existing islands of automation into a single data source for all functions—will support this network. Companies such as Kroger plan to use this as a means of increasing shelf use in retail stores so that inventory can be adjusted throughout a single day to reflect changing consumer demand patterns at different times. These technologies also enable creation of an end-to-end "chain of custody" for total asset visibility. Data standards to synchronize and integrate the global value chain are sorely lacking at this time, which hinders broader adoption of the technologies. Nonetheless, data are becoming more granular, more prevalent, and richer than ever before, and RFID technologies will increase this trend dramatically.

Ms. Grackin closed by noting that the rate of adoption is accelerating; more versatility and application capability will be built into RFID layers, users will increasingly shift to net-hosted intelligent networks to support their business processes, and many poor performing networks may fail because they aren't able to scale to match data needs.

SUPPLY CHAIN 2020

Dr. Larry Lapide, PhD, described Supply Chain 2020 (SC 2020) sponsored by the Massachusetts Institute of Technology (MIT), a multiyear, global research initiative on supply chain management guided by an Industry Advisory Council for U.S. input and a European Advisory Council to focus European and international input. The initiative is intended to answer two fundamental questions: "What will supply chains look like in the year 2020?" and "What should companies do to prepare for 2020?"[1]

Researchers are exploring external factors—such as the legal environment, trade policies, technology, and the competitive landscape—along with supply capabilities—such as manufacturing methods, distribution methods, IT, and materials science—to determine likely future scenarios for supply chain operations. MIT is researching the impact of supply chains on operational and financial performance at individual companies by reviewing the findings of 25 recent studies on the topic. The review corroborates the premise that supply chain performance affects both short-term financials and market share. MIT has concluded that an excellent supply chain (1) supports, enhances, and is an integral part of a company's competitive business strategy; (2) leverages a distinctive supply chain operating model

[1] Information on SC 2020 can be found at www.supplychain2020.net or www.sc2020.net.

to sustain competitiveness; (3) executes well against a balanced set of operational performance objectives and metrics; and (4) focuses on a few business practices that reinforce each other to support the operating model and best achieve operational objectives.[2]

The SC 2020 researchers are also comprehensively searching the literature for likely possibilities for supply chains of the future. The consensus emerging from this search is that the future is likely to see highly interconnected global supply chains, links that are fluid and transient, boundaries open to free flow of goods and services, information flowing freely and shared widely among trading partners, and innovative technologies that support these attributes. The search also reveals, though, that the consensus opinions on future supply chains are inconsistent and utopian, that the literature depends too much on extrapolations from current trends, and that a scenario planning approach is needed.

Dr. Lapide also noted that global macroeconomic trends, particularly those in motion in China and India, are likely to greatly impact the supply chains of the future. The U.S. share of global gross domestic product peaked in 2004 at 31 percent and is likely to fall over the next several decades as other economies mature. This will create a relative change in living standards, potential material shortages, an increase in interbusiness competition, and much higher prices for energy and commodities.

FUTURE TRENDS IN LOGISTICS TECHNOLOGY

Colonel William Fry, Commander, U.S. Army Medical Materiel Agency, described logistics technology trends with bearing on the medical logistics community. He began by noting that affordability, rather than desirability, often drives DoD actions. He then summarized the Army's ongoing ERP partnership with the Defense Logistics Agency (DLA), which has produced tangible operational benefits through the implementation of SAP software under the Army's Theater Army Medical Management Information System (TAMMIS) Enterprise-Wide Logistics System (TEWLS). This project—a precursor to the JEWL-M initiative described by Butch Hammel of the DMLSS program—is targeted at reducing the hundreds (or even thousands) of separate databases now used in the legacy environment by replacing that environment with a single-instance ERP system supporting the entire enterprise.

COL Fry echoed BG Ursone's comment that "in peacetime, the military has plenty of time and no money; in wartime, there's plenty of money but no time" as a means of illustrating the need for integrated enterprise solutions with

[2] These operational objectives include customer response (customer-facing), internal efficiency, and internal asset utilization. Customer response metrics include order cycle times, perfect order fulfillment, quality, and new product time-to-market. Efficiency metrics include labor productivity and supply chain costs, and asset utilization metrics include facility utilization, inventory turns, and inventory value.

point-of-care to source-of-supply capability. He also stressed that in the future, communications and connectivity need to be emphasized, even if that emphasis comes at the expense of the current emphasis on point-focused hardware and software functionality. Without data communications, the future enterprise will be paralyzed. COL Fry compared the Army medical logistics with FedEx to describe shortfalls in the current environment, saying that Army medical logistics is roughly analogous to FedEx—that is, *if* FedEx didn't own its own trucks or planes and didn't have its own communications system.

COL Fry next summarized the military's views on a variety of commercial medical product types and logistics technologies. He observed that the military medical logistics community still hasn't formulated the business case for the use of passive (second generation) RFID technology, although the potential benefits are clear. He also noted that the current DoD mandate for vendor use of RFID may or may not produce the desired result. He commented on point-of-use technology (such as Pyxis or Omnicell automated supply cabinets), noting that no plans for its use in deployable medical organizations have been made, even though deployable hospitals have fewer logisticians and supply technicians.

Regarding laboratory reagents, COL Fry noted that reagent technology has only advanced marginally with regard to logistics sustainability. Much more progress is needed to improve the environmental survivability of reagents, extend shelf life, and simplify or standardize reagents for cross-platform, multimanufacturer compatibility. Progress is also needed in the processes used to store and manage blood products. Whole blood products have been only marginally optimized for logistics sustainability in the last 10 years, and frozen blood products are probably not suitable for mass casualty scenarios because of the time and equipment needed to prepare them for use.

Power generation technologies are similarly not as advanced as they should be and are unsuitable for future military operations. Even though medical organizations require vastly more electrical power than before, power generation capability has not kept pace, resulting in deployable organizations that are woefully underpowered. The need for water on the battlefield, and especially in battlefield medical organizations, has grown dramatically as well. Like power technology, water generation technology has not kept pace with the requirement.

Oxygen generation is one area showing tangible improvement. The availability of the expeditionary deployable oxygen concentration system (EDOCS) and portable oxygen generation system (POGS) technologies has eased the problems previously associated with oxygen generation. COL Fry also commented that new transportation technologies, such as the Integrated Lines of Aerial Resupply System (ILARS) now being researched, may also provide relief.

COL Fry concluded his remarks by noting the urgency of finding and fielding affordable, sustainable, integrated capabilities—America's soldiers depend on our ability to make things better.

MOBILE COMPUTING AND BMIST

Mr. Tommy Morris, Chief Information Technology Officer, TATRC, described the mobile computing mission at TATRC, which focuses on the identification and development of mobile computing solutions integrated with existing wireless infrastructure in support of Army, Navy, Air Force, and Marine Corps operations. He noted that his programs have their origin in the gaps historically found in battlefield medical record keeping and data collection, the need for a longitudinal medical record throughout the various nodes in the military medical treatment chain, and the continuing changes in military missions, environments, and requirements.

Mr. Morris noted that the BMIST platform is being acquired, tailored to military needs, and inserted into the Theater Medical Information Program (TMIP) acquisition process to allow the military to quickly acquire the rapidly evolving commercial technology on which it is based. BMIST provides an all-in-one suite of mobile applications that empower providers with critical information and decision and clinical support tools to accurately create an electronic health record. BMIST is able to synchronize its data with a variety of medical information systems, although specific interfaces have not yet been created for all of them.

The federal government is now using over 5,000 BMIST devices and expects to use 20,000 by the end of 2005, 35,000 by FY06, and 50,000 by FY07. BMIST has broad civil-military application in a variety of settings, and other nations are studying its civil and military use. BMIST use in developing countries could potentially provide international medical surveillance capability now lacking in those countries.

BMIST is also compatible with electronic personnel information carriers (and eventually with wireless carriers) and can thereby be used to provide up-to-the-minute updates to patient-carried medical records. By creating electronic patient records, BMIST also facilitates automated analysis of trends and statistical patterns.

TATRC has selected commercial pocket PCs as the basic platform for its product because of their affordability, durability, and adaptability to customized military uses. BMIST generates its output files in XML format, uses C++ programs for its custom-developed applications, and will soon be ported to a .NET development framework. TATRC selected the iPaq platform because of its ease of use, mobility, multithreading capability, security, display quality, and expandability. Future applications of the BMIST platform will include medical supply, medical maintenance, blood products management, and other clinical and clinical support.

OTHER EMERGING TECHNOLOGIES

Dr. Gary Gilbert, PhD, summarized TATRC activities related to a group of emerging technologies: tissue engineering, nanoscience efforts, microelectromechanical systems (MEMS), robotics, and others. Applications for these technologies include engineered human tissues for repair of trauma damage, fabrics and packing materials engineered to withstand enormous combat-induced shock, and robotic delivery, casualty retrieval, or evacuation platforms, to name a few. Other possibilities include super-survivable nanoengineered materials for personnel or platform protection.

Dr. Gilbert also gave a short video presentation on the multiple-function utility logistics equipment (MULE) prototype offered as a candidate capability for the Army's Future Combat Systems program. Lockheed Martin developed the MULE prototype as a multiuse, modularized, autonomous or remote-controlled platform with a variety of potential command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); weapons; logistics; and medical modules integrated into the basic platform. The Army intends to make one-third of its vehicles autonomous by 2015 because of their advantages in deployability, cost, survivability, and adaptability.

Other autonomous robotics programs include the Army Program Manager for Force Protection's Tactical Amphibious Ground Support (TAGS) program, which may include a medical variant for patient extraction and evacuation. This medical variant will be a "system of systems" with a "marsupial" payload for reconnaissance and casualty assessment, casualty transport bays, and a second marsupial payload for casualty extraction. The variant could potentially be integrated with the Life Support Trauma and Treatment (LSTAT) "super litter" to reduce exposure of medics and other personnel to hostile conditions while improving patient evacuation. All of the robotic systems will be Joint Architecture for Unmanned Systems (JAUS) compatible for interoperability and integration with C4ISR systems.

Dr. Gilbert concluded his presentation by commenting briefly on efforts to develop an unmanned aerial vehicle capable of autonomous or guided patient evacuation.

BREAKOUT GROUPS

Four breakout groups—one for each focus area, enterprise integration, asset management and visibility, supply chain management, and materials, energy, transport, and the environment—formed near day's end to develop a construct for the development of a logistics technology roadmap, which will serve as the principal output of the IRT. The workgroups met for about an hour and formed individual team approaches, established workgroup leadership and recording roles, and made plans for the development of a logistics technologies research roadmap.

Chapter 3
Seminar Day Two

DoD Medical Logistics—2005

Colonel Don Buchwald, Director of Medical Materiel, DSCP, reviewed DSCP's recent activities, including its role in the DLA Class VIII Executive Agency initiative and recent developments in the readiness domain. He noted that DSCP's medical sales are now well over $2 billion annually, even though medical directorate staffing and DLA inventory levels continue to decline. DSCP Medical's increased efficiency has enabled Class VIII cost recovery rates to stay well below the rates of all other DLA-managed supply commodities. Four divisions (pharmaceuticals, medical-surgical supplies, equipment, and readiness) make up the Medical Directorate, which recently awarded a 10-year, $20 billion contract for its third generation pharmaceutical prime vendor program, which includes an average *negative* 5 percent distribution fee.

DSCP participates with the Department of Veterans Affairs (DVA) to obtain a single federal price for pharmaceuticals, along with a range of joint national-level contracts. Key initiatives in the medical-surgical and equipment divisions include expanded use of electronic commercial catalog (ECAT) offerings, substantial increases in DoD/DVA joint acquisition, and a focus on patient movement items used to support medical evacuations. Readiness strategies focus on planning for resupply requirements, investments in contingency materiel, improved business intelligence to better plan contingency support needs, and investments in IT applications supporting readiness. DSCP uses a continuum of support strategies, including prime vendor contracts; a diminishing but still necessary use of DLA-owned depot stocks; direct vendor delivery contracts; support for electronic data interchange (EDI)-based item purchases; "surge" contracts for readiness support; vendor-managed inventory for readiness support; a variety of contingency contracts, also for readiness needs; and a number of new acquisitions, which are increasingly offset by the other strategies.

In the 1991 Gulf War, 92 percent of the military's readiness needs were met by the much less responsive new acquisitions, and 8 percent were met using depot stocks. In current operations, 39 percent of all needs were new acquisition, and the remainder were satisfied through use of the other strategies, which meant greatly improved response.

Recent readiness successes include DSCP's partnership with the Army's southwest Asia distribution operations, along with greatly expanded use of prime vendors to meet readiness needs. The "last tactical mile" of in-theater distribution remains a challenge.

In August 2004, DLA was designated the Class VIII Executive Agent, which will lead to increased partnership with the services, improved collaboration during contingencies, and lead agent designations for key organizations to enhance the partnership relationships.

Data synchronization remains a key challenge as DSCP works to improve the global medical supply chain. Nonsynchronized, nonstandardized data produce unacceptable bottlenecks and costly errors in the increasingly automated, e-commerce-enabled supply chain. DSCP is supporting an industry-led initiative to create a product data utility (PDU), which will provide a clearinghouse function across the healthcare industry to synchronize and cleanse healthcare product data. An accurate PDU also facilitates a move to RFID strategies to further automate the medical supply chain. DSCP is now beginning Phase II of its PDU pilot project, building on Phase I, which synchronized a limited number of products and organizations and which resulted in the creation of a web-services-enabled "MeditemLink" application to automate data synchronization. "E-collaboration" is the hallmark of DSCP's relations with its customers and trading partners.

SUPPLY CHAIN EXCELLENCE: DELL PRACTICES

Mr. Mike Gray of Dell, Inc., gave a "supply chain evangelist's view" of supply chain management strategies. He differentiated Dell's supply chain from that of DoD, noting that Dell is a 21-year-old company without the disadvantages of legacy systems and data and that it has not faced the integration and consolidation challenges DoD faces in its Executive Agency and other joint initiatives. He also noted that companies around the world, including Dell, are challenged by the difficulties of creating synchronized supply chains.

Customization, along with speed and the need to simplify processes, are also increasingly important for both Dell and healthcare supply chains. There are major differences, though. One is that Dell's major suppliers number about 40, and the total supplier base is only 400. Its commitment to quality includes a commitment to Six Sigma statistical techniques to eliminate variation and waste in the supply chain. Dell's manufacturing process can be referred to as RRF, FIFO (a *really, really fast* implementation of *first in, first out* management practices). In fact, Dell's model is *so* based on this concept that reverse logistics is now one of the company's biggest challenges. Although Dell's entire process uses only a few thousand parts, possible combinations in the made-to-order process number in the millions.

Dell's revenues now exceed $51 billion annually, and the company employs 57,600 employees worldwide. Each of Dell's seven worldwide manufacturing facilities is exactly the same, and each uses the same processes throughout. Its business model is based on five principles: most efficient path to the customer, single point of accountability, low cost leader, build-to-order, and industry standard technology. Other attributes include an undivided focus on customer satisfaction

and complete continuity of supply. Dell's sales model is based on the premise that computer component prices are continuously falling, which means that Dell is rewarded financially by deferring the purchase of components until the last possible moment. In other words, by collecting sales revenue an average of 39 days earlier than payments are made to suppliers, Dell maximizes profit, leverages its use of approximately $4 billion in "float" supplies of cash (yielding an average of $480 million in profit) and is able to turn its inventory an average of 91.5 times annually (average days of supply on hand runs at about 4 days). Competitor companies are as of yet not able to adopt the build-to-order model.

Dell reschedules its factories every 2 hours to adapt to incoming customer orders, and the planning horizon for factory operation is focused solely on the 0- to 3-day horizon. Dell's model also operates with six times more people in worldwide procurement strategy and four times more in materials planning than in production operations. On-site inventory at the production site is limited to a few hours, and inbound inventory is limited to 10 to 25 days. Dell has complete visibility and control of its inbound supply chain, allowing it to redirect inventory, adjust the inbound speed, and otherwise regulate the supply chain. This model requires complete synchronization between sales and production operations. Dell's experience is that the increased speed of its supply chain actually increases quality. In the modern world, logistics has replaced manufacturing as the most significant cost driver. As fuel costs rise, this will only increase. Dell uses an "8-pound rule" to determine the proximity of manufacturing facilities to the customer center of mass. If a Dell product weighs less than 8 pounds, it can be assembled in the location that makes most sense in terms of operating expenses and efficient inbound logistics; if it weighs more than 8 pounds, the product is assembled in the location that optimizes outbound logistics.

DoD RFID Strategy

Mr. Paul Donato, senior consultant with IBM Public Sector, discussed DoD's RFID strategy on behalf of the Assistant Deputy Undersecretary of Defense for Supply Chain Integration. He spoke of the broad benefits of RFID, its importance in a synchronized supply chain, and DoD's goals for RFID implementation.

DoD's implementation of "active" RFID technology is now operational, and "passive" devices are being implemented now, and suppliers were implemented as of January 2005. DoD is reviewing acquisition regulations to build support for the RFID strategy into the acquisition process. The proposed Defense Federal Acquisition Regulations (DFAR) clause specifying DoD's RFID policy is out for public comment. Schedules for implementation of the policy are incremental. Selected classes of supply (II, VI, IX, and part of Class I) are included in the 2005 date for selected levels of tagging and "ship to" locations (limited at this point to DLA distribution centers in San Joaquin and Susquehanna); all other classes will

be added in 2006, again for selected levels of tagging and "ship to" locations. Final implementation for all classes of supply, tagged at all levels of packaging—down to the unique identification (UID)/item level—and all "ship to" locations is envisioned in 2007. Additional education, outreach, and testing will accompany the implementation of the RFID policy.[1]

RFID AND HEALTHCARE

Dr. In K. Mun and Mr. Don Neuwirth discussed MIT's Healthcare Research Initiative and its work related to RFID in the healthcare environment. RFID in the healthcare environment must be more reliable, accurate, and affordable than in any other setting.

Healthcare Process

Dr. Mun's work with RFID began with the release in 2000 of an Institute of Medicine report that attributed at least 40,000 deaths annually to errors in the management of medical data. He noted that barcoding has not produced data control and accuracy benefits sufficient to overcome this problem and summarized the advantages of RFID as a better means of addressing it. RFID must demonstrate several benefits before it will be widely implemented in U.S. healthcare, including cost-effectiveness, clinical or operational benefits, reliability and standards compliance, a clear path for technology upgrades, and the ability to reduce or eliminate liability issues.

Dr. Mun also spoke of MIT research on the effects of radio frequency (RF) energy on pharmaceutical products, including specialized medications with less stable chemical formulations; mass serialization methods and their security implications; recommendations on the most appropriate RFID frequencies for the healthcare environment (necessary because different frequencies interact with metals, ceramics, fluids, and other materials used in healthcare); data constructs for RFID numbering schemes, including assessments of enforceability and protections for intellectual property; backup measures in the event RFID devices fail; methods of interfacing RFID information with healthcare IT applications through protocols such as HL7, XML, or DICOM; improvement of controlled substances management; RFID-enabled e-pedigree improvements; and methods of improving a variety of healthcare business processes, workflows, and asset management practices through the use of RFID. For example, national averages for utilization of healthcare equipment run about 45 percent; the average hospital writes off as much as 10 percent of its inventory each year; and annual equipment theft costs the average hospital as much as $500,000 per year. Each of these figures could potentially be improved through intelligent application of RFID technologies.

[1] See www.dodrfid.org for more information on DoD's RFID policy and implementation plans.

Dr. Mun concluded by noting that military uses of RFID will likely stretch the technologies to their limits due to environmental, operational, and integration challenges.

Managing Healthcare Assets

Mr. Dan Neuwirth of Agility Healthcare, Inc., described the emerging uses of RFID in the management of healthcare assets. Locating assets is the most commonly discussed use, but the true potential of RFID is much greater. However, using RFID to more closely monitor an ineffective or inefficient business process may only add cost, slow cycle time, and cause confusion instead of producing benefits.

When implemented properly, RFID can be deployed in a hospital or other healthcare setting to control distribution flow; enhance condition monitoring, maintenance planning, diagnostics, and replacement and upgrade processes; control rental equipment; improve management of assemblages and assemblage components; improve event management in healthcare or healthcare logistics business processes; improve management of consumables; and track patients and monitor patient care processes.

RFID IN SUPPLY CHAIN AND LOGISTICS

Mr. Mark McDonald of Alien Technology, Inc., described its RFID projects to automate supply chain and logistics operations. He noted several technological limitations affecting RFID implementation, including the inability of RFID to interrogate or transmit signals from within a metal container and the effect of water on RFID devices. Industry will find ways to adapt the technology to these limitations, and RFID use is likely to explode over the next 2 to 5 years. Alien has shipped over 50 million passive RFID tags to a variety of retail firms, DoD, and other users, and has the capacity to manufacture 1 billion tags annually, with a near-future capacity of 11 billion per year.

Alien designs and manufactures a variety of devices based on passive, battery assisted passive (BAP), and active technologies. In a recent pilot project for DoD's combat feeding program, Alien was able to use condition-monitoring data recorded on BAP tags to do conditional management of shelf life on the basis of environmental conditions over time. In this project, Alien outfitted material-handling equipment with RF readers to facilitate automated collection of temperature profiles. Readers then fed quality management systems, which assessed food quality, and performed condition assessments on the basis of the results. Other applications could include long-range identification, location tracking, and sensor integration for a variety of sensor capabilities, including tethered sensors that can be placed at a tethered location remote from the tag itself. Longer-range developments will include infrared communication ability, increasing miniaturization, and antenna and circuit printing technology to produce very low cost devices. The

business process changes these developments will almost certainly enable are for the most part unclear.

Emerging Complexity in Supply Chain Management

Dr. Oliver Hedgepeth, PhD, of the University of Alaska, Anchorage, spoke on the business challenges of the complexity of tomorrow's supply chain. As information about products, processes, and events proliferates through the use of RFID and other technologies, supply chain managers and systems will be confronted with unprecedented challenges. This complexity increases as multitier supply chains of suppliers and customers proliferate. At the same time, logistics management functions are now thought of as an integrated "bundle" of what were previously fragmented planning, production, storage, and transportation functions.

Dr. Hedgepeth commented on the likely emergence of new transportation technologies, such as lighter-than-air transport vehicles with large payloads, improved velocity, and lower costs than existing aircraft, and other challenges such as cold chain management and temperature variations. He contended that RFID will change the world as much as computers have. Because industry forces are driving RFID implementation, it is likely to disrupt businesses, the military, and other users. Data about the supply chain will become billions of times more available as a result of RFID, and its use will become critical to future success.

The "emergent properties" that will emerge from this volume and its taxonomy are unclear. As the technology develops more fully, a threshold beyond which business process change will be nonlinear and unpredictable is likely.

Point-of-Sale Technology in Medical Logistics

Mr. Ralph Cadwallader of Cardinal Healthcare/Pyxis presented new concepts in point-of-sale technologies and their potential application to the military medical logistics supply chain. Pyxis automated supply cabinets are used in healthcare environments to track the use of consumable supplies, pharmaceuticals, and other products. When integrated with hospital logistics systems like DMLSS, Pyxis provides an appropriate point-of-use platform for managing a wide range of products. In the near future, Pyxis platforms will incorporate RFID technology, sensors, and other technology to permit such capabilities as automated reordering based on the weight of products on a Pyxis shelf and other parameters.

Pyxis automated supply cabinets are now integrated with a key-fob-sized, battery-powered RFID device (JITrBUD), which can be used to communicate directly with the supply cabinet for remote recording of transactions. Each Pyxis cabinet

can manage up to 500 JITrBUDs. They can be used, for example, to record individual issues from a non-Pyxis storage location to a Pyxis cabinet, which can then present transaction data to the hospital logistics system. Alternatively, JITrBUDs can be interfaced directly with the logistics system in a non-Pyxis environment. Environmental limitations of the JITrBUD are unknown at this point. Each JITrBUD in the current construct is associated with an individual item and location and requires item-by-item "tagging" to associate the tag with the item or location.

COLD CHAIN MANAGEMENT

Ms. Carla Reed of ChainLink Research outlined the increasingly complex and important issues related to cold chain management as a subset of global supply chain management. She explained that *cold chain* refers to the subset of the supply chain that involves the production, storage, and distribution of products requiring some level of temperature control to retain their essential characteristics. Cold chain management becomes more difficult in the informal or rapidly developing supply chains that characterize most military operations. Advanced sensor, wireless, and RFID technologies are potential components of a future model to improve cold chain management through continuous monitoring and reporting. Other improvement methods may include temperature-sensitive labeling, color-coding systems to identify cold chain product types (frozen, cold, cool, temperature controlled, etc.), and specialized packaging for cold chain management during transit. Although these technologies will cost money to implement, traditional models for computing return on investment are inappropriate: the risk management/risk avoidance model better pertains because a disrupted cold chain can have disastrous consequences in the world of healthcare.

The problem, according to Ms. Reed, is potentially huge: Centers for Disease Control and Prevention (CDC) has estimated that 17 to 37 percent of vaccines are exposed to improper storage temperatures. Although a number of organizations develop and disseminate policy and guidelines for cold chain management, no uniform method ensures harmonization of policies or regulation of practices. As technology continues to enable the real-time, electronic monitoring of supply chain operations and the flow of material through the supply chain, care should be taken that cold chain management is a part of the monitoring process. The weakest link in the cold chain may well be the last tactical mile, in which extreme conditions or unpredictable distribution methods may negate careful handling earlier in the process.

Ms. Reed concluded by noting that ChainLink is the fastest growing supply chain research and advisory company. One of the most widely seen ChainLink products is the magazine *Parallax View*, an iconoclastic trade journal covering a variety of supply chain topics and read by over 200,000 industry professionals.

ADVANCES IN MINIATURIZATION

Dr. Randy Haluck, MD, of Penn State's Hershey Medical Center provided insights about miniaturization of devices and materials in healthcare. New technologies for the design and manufacturing of ultraminiature devices are helping to overcome some of the limitations of present-day laparoscopic instruments, such as the limited dexterity, inefficient mechanical energy transfer, and limited range of motion they permit. As in other areas, MEMS technologies offer great potential in the design and manufacture of microminiature instruments and devices. Compliant mechanisms (single-piece flexible structures that exploit elastic deformation to achieve motion transmission, such as microminiature tweezers) also offer promise. Metal fabrication with great precision in the 100- to 300-micron range is now possible. Electroactive polymers (flexible materials in which piezoelectric actuators can produce mechanical motion) are yet another technology being developed at Penn State's materials research facilities. Piezoelectric devices are also succeeding in the creation of miniature electric motors 1/10 the size of the smallest motors now possible. Motors as small as 1.5 mm in diameter by 4 mm in length are being built for optical, surgical, and other purposes, including use in microrobots as small as 2 by 3 by 3 cm in size and maneuverable with great precision by remote actuation. Endoscopic advances may include devices incorporating these motors along with miniature cameras or other sensors that can be inserted into the bowel and maneuvered remotely.

Potential challenges posed by these devices include not being visible or identifiable with the naked eye, presenting problems with labeling, packaging, and standards. They may require integration with other control or data acquisition systems although the physical means of connecting such a device doesn't yet exist. Tracking, testing, and using these devices may be nearly impossible without the use of microscopes. Implications for patient safety, worker safety, risk management, training, sterilization, auxiliary equipment, and packing, shipping, and storing are all beginning to emerge.

ADVANCES IN ENERGY RESEARCH

Mr. David Scharett, senior research scientist with Pacific Northwest National Laboratory, described a number of advances in the field of energy research. He began with the current energy requirements for modern military operations, which continue to increase dramatically as more electronic and power equipment becomes ubiquitous. As energy requirements increase, the cost of supplying it is also increasing—the cost to deliver a gallon of gasoline on the battlefield may be as much as $600 to $700 per gallon when all delivery costs are totaled. Certain emerging technologies may offer a partial solution. For example, many batteries now use nanofiber carbon technology, which is 60 percent more efficient as a storage medium than earlier technologies. Renewable power and energy sources may offer unprecedented durability and reliability. As an example, the Sterling engine designed for NASA can operate for as long as 10 years without refueling,

and alternative batteries such as “alpha emitters” (nuclear) may provide the capacity to store as much as 150,000 times as much energy per milligram as conventional lithium-ion batteries. Nuclear microgenerators based on piezoelectric technology and controlled by a microchip may power communications, micromotors, and other ultraminiature devices. Nanocomposite photovoltaic materials may produce usable energy in quantities sufficient to power HVAC equipment; embedded prognostics, diagnostics, or regulators such as miniaturized pacemakers; autonomous communications equipment; or unmanned aerial vehicles for ultra-high-altitude winged flight. These photovoltaic materials can be “painted” or sprayed onto wing surfaces, roofs, and other surfaces.

Fuel cell technologies powered by methanol, solid oxides, acids, or alkaline compounds may offer significant reductions in energy expenses when mature. Fuel cells have a theoretical efficiency of as high as 90 percent, compared with 20 percent for gasoline and 30 to 35 percent for diesel fuels. This efficiency could produce power generation savings of as much as 50 percent and deployment airlift reductions of 16 percent for operational military forces. Miniature “direct methanol” fuel cells are now being used by special operations forces in southwest Asia to power laptop computers (2 cc of methanol can power a laptop for 20 hours); other fuel cells as small as 2- by 1- by 1/4-inch are being used to power prototype cell phones and other devices. Some of these devices may enter the commercial marketplace later this year.

The gradual conversion of the U.S. economy from one based on fossil fuels to one based on hydrogen is already beginning, and every major company in the energy industry is exploring hydrogen technologies today. Most experts now believe that the United States may be fully hydrogen based within as little as 35 years, and Mr. Scharett provided a list of dozens of industry, government, and academic organizations around the world that are conducting research into a variety of issues, applications, and related technologies.

Other new and extreme-density energy sources may further revolutionize the U.S. and world economies. A decade of research into antimatter indicates that practical means of antimatter production and exploitation may be within reach. If realized, this potential could provide virtually unlimited energy from sources of incredible density: one button-sized cell of antimatter could provide 123 times the energy of the space shuttle at time of liftoff, or enough energy to power an armored vehicle on the battlefield for more than 30 years of continuous operation without refueling. Nuclear fusion, while still only a remote research possibility, could provide even more energy with even greater efficiency.

The accelerating pace of technological development means that goals that now seem remote may be closer than they appear. It should be possible to assess the feasibility of many of these research possibilities on the basis of the amount of corporate investment, patent and trademark activity, research sponsorships, papers published, and other indicators of viability.

ADVANCES IN WASTE STREAM MANAGEMENT

Dr. James Garvey of State University of New York–Buffalo described a new technology, based on the "bioblower," which rapidly and continuously cycles large amounts of air (or aerosolized liquid) while simultaneously sterilizing the entire flow as it passes through the blower mechanism. The sterilization is based on the principle of compression, which describes the physical fact that compression of a gas causes uniform heating of the gas. As volume decreases, pressure and temperature increase uniformly and almost immediately.

The pump used to compress the gas is a widely used, affordable, and increasingly powerful blower, called a Roots blower, based on rotating, opposed rotors in an enclosed casing, which cause a series of small compressions known as "multi-recompressive heating" (MRH). Developed in 1967, MRH had no commercial application until now. Proof-of-concept tests included heat-treating of anthrax-like spores injected into an airstream moving into and through the Roots blower. Downstream sampling of airflow beyond the blower showed extremely high kill rates—as much as 99.9 percent—for all sampled spores, despite their being in the rotor casing for no more than a few milliseconds. The apparent mechanism by which the spores are killed is the MRH inside the blower, and the threshold pressure at which efficacy is optimized is an internal pressure level that produces heating of 200 ºC in the continuous airflow.

DoD's Joint Program Office for Collective Protection is studying the bioblower concept, and it will likely be subjected to formal or informal operational tests and evaluation. If tests prove the concept's value, SUNY–Buffalo intends to establish a commercial subsidiary to bring the bioblower to production and to begin selling the devices to DoD as early as 2006.

The heated air exiting the bioblower may have other uses. A heat exchanger downstream from the rotors may circulate energy extracted from the hot air to preheat the upstream air to reduce the energy needed to power the bioblower by as much as 90 percent. Future work includes testing with lethal rather than benign spore types and viruses, engineering to create more efficiency, integration with HVAC systems, and building and testing a variety of prototypes.

ADVANCES IN OXYGEN AND WATER PRODUCTION

Mr. Tarik Naheiri of Pacific Consolidated Industries (PCI) described recent progress toward improved capability for medical-grade oxygen and potable or sterile water treatment and production. Mr. Naheiri noted that these capabilities may enable the elimination of entire segments of the supply chain since the oxygen generators may have corollary benefits useful in the production of potable or sterile water. Modification of the current EDOCS system may provide the desired means.

PCI has deployed over 100 EDOCS units to Iraq thus far, which through modification can potentially augment the reverse osmosis purification process now used by the U.S. military to produce hospital-grade (but not injectable) water. One reverse osmosis water purification unit (ROWPU) has a capacity of 600 gallons of potable water per hour, weighs 8½ tons, and is the size of a small house trailer. Modifying the EDOCS device through addition of a small ozone generator could enable the EDOCS to produce purified water in addition to medical-grade oxygen. The resulting device is known as a Hospital Oxygen–Water System (HOWS). A single water purification device of this type could potentially use nonsaline wastewater as an input and produce nearly 100 percent of sterile water for hospital use. Moreover, the use of ozone eliminates the odor and taste problems normally associated with water purified using only a ROWPU.

PCI is now exploring other membranes and materials that may be able to extract protein fragments through filtration, separation, and chromatography methods that bind protein in a variety of polymer screens tailored to the particular contaminants in the water. Polymeric membranes of this type can be as small as 10 cm long, and the polymers themselves can attach to molecular chains capable of filtering a very wide variety of contaminants. The device can produce as much as 5 gallons per minute of potable water and 5 gallons of sterile water with minimal power requirements. Further work is necessary before acquisition and deployment, and the Food and Drug Administration will have to review and approve the device before acceptance as a source of injectable water.

Environmental Control in Medical Environment

Dr. Thomas Hughes, PhD, Assistant Director of Penn State's Energy Science and Power Systems Division, discussed a proposed modular unit that integrates a variety of environmental control and production devices, including power management and distribution functions. The device would be modular, based on commercial products requiring only limited modification, operate on readily available fuels, integrated for optimal balance of weight, efficiency, and durability characteristics, and based on existing or emerging technologies. Creating the proper balance of these attributes, many of which typically occur in inverse to each other (weight and efficiency, for example, or efficiency and durability) will require a complex set of engineering and design attributes and sophisticated tradeoff analysis.

A variety of emerging technologies have potential uses as components or contributors to the integrated device desired, including fuel cells, advanced batteries, Stirling converters, mini-Brayton systems, flywheels, ultracapacitors, and thermoelectrics or thermophotovoltaics. Fuel cells are promising because they are scalable and quiet, but many are also complex and based on sophisticated energy

extraction methods that increase cost and reduce efficiency. The National Academy of Sciences recently reviewed fuel cells and concluded that short-term benefits were minimal compared with those available already from automotive diesel engines. Battery systems offer potential but have other shortcomings. As batteries are combined in large arrays for greater power, they produce relatively less power as the arrays grow in size. Engine technologies are also advancing, and engines such as the Stirling converter engine can be propane-powered, as much as 44 percent efficient, and both simple and reliable. Heat engines, which use differentials between two different temperatures at different points in the engine, have significant potential but are not designed to operate across a range of power outputs.

Dr. Hughes also described a number of electrical generation devices, miniature turbines, and other devices based on available commercial technologies, all of which have some potential for adaptation to military use. Flywheel technologies, according to Dr. Hughes, are useful, but not practical when safety and power management considerations are added to the equation. Thermophotovoltaics and thermoelectric devices are also problematic.

Oxygen sources, consisting of oxygen bound with other chemicals, are possible, and Penn State is exploring techniques that would permit the recombination of free oxygen where necessary. Dr. Hughes described a notional integrated system with a relatively low thermal signature, power management and distribution capability, a Stirling engine as a power source, and substantial power and oxygen output. The notional system should be refined iteratively through discussion with technologists, and continuing difficulties surround the means used to integrate emerging technologies and requirements. Because the military needs relatively small quantities of such integrated devices, it is unlikely that a purely developmental approach would produce an affordable product. If the military uses a purely COTS approach, it is unlikely to find a satisfactory, commercially integrated solution. This suggests that a nondevelopmental approach, integrating commercially available technologies, is the only approach likely to produce a product that bundles the technologies onto a single platform, remains affordable, and meets military requirements.

PANEL DISCUSSION

Following the preplanned individual presentations of Day Two, IRT participants opted to bring industry and academia representatives back to the podium in a panel discussion format for an informal question-and-answer session. Two focal points emerged during the session:

- Attendees posed specific questions on the technologies discussed throughout the IRT.
- A more free-form dialogue unfolded to characterize the environment, culture, options, and constraints characterizing the medical logistics product portfolio and its management in the military setting.

Panel participants suggested that clearer definitions of the medical logistics enterprise and its inputs, controls, mechanisms, execution, and outputs could improve predictability, control, and accuracy for military medical supply chain operations. Given the dynamic, fluid, and sometimes chaotic nature of military operations, this is both a necessary and very challenging objective.

Chapter 4
Seminar Day Three

BREAKOUT GROUP SESSIONS

In Day Three, the IRT returned to the breakout group format defined in Monday's session. As done on Monday, group leaders were designated from among the senior leaders at the IRT, and four groups were constructed with a focus on the four areas represented in the IRT: enterprise integration, asset management and visibility, supply chain management, and materials, energy, transport, and the environment.

The groups were asked to form draft concepts or documents for incorporation into the medical logistics technology research roadmap. We will draft this roadmap by synthesizing the material presented during the IRT, the draft concepts fashioned by the four groups, and other sources, including military medical science and technology objectives and input from Military Health System (MHS) and industry leaders. Each group received a set of questions designed to provoke discussion and define parameters for the breakout sessions:

- What is the current baseline or definition of your focus area and the functions, systems, and organizations it includes?
- What are the desired objectives? What are the problems you'd like to solve?
- What issues and barriers prevent you from achieving the desired objectives?
- What new capabilities are needed to address these issues? How should they be prioritized?
- What should our transformation research roadmap be for the short term (1–2 years), the mid-term (3–4 years), and the long term (5 years and beyond)?

Participants were advised to consider technology research opportunities in the context of internal (in the MHS) and external medical logistics organizations and relationships, policies that impact medical logistics operations, and the process or program framework in which medical logistics operates.

Enterprise Integration Focus

BG Ursone summarized the work done by the enterprise integration focus group, which focused on the six areas of research that have the greatest potential to support enterprise integration goals. The consensus was that the Medical Logistics Proponent Subcommittee (MLPS) should manage and coordinate medical logistics research to ensure consistency with broader enterprise goals and initiatives. The group also emphasized the increasing need for standards, protocols, and other frameworks to create unity of effort and interoperability.

Table 4-1 illustrates the priorities and likely time horizons for the six research areas of greatest potential. The enterprise integration group also saw the need for

- improved modeling, simulation, and business intelligence tools to estimate wartime requirements and to improve linkages with vendors;
- joint capabilities and management processes for research and development, including a possible joint testing and prototyping laboratory for logistics technology; and
- more standardized data to enable the transition to a net-centric, web-services capable enterprise architecture.

As these capabilities mature, they may set the stage for the transition to a joint medical logistics structure and will enable the use of other technologies, such as distance learning, improved integration with suppliers, third-party distributors, and transporters. The group acknowledged that these capabilities must also be linked to the combatant commands (COCOMs), line logisticians and transporters, and IM/IT community, including providers of communications infrastructure.

Table 4-1. Enterprise Integration Group Prioritized Activities List

Priority	Medical logistics technology area	Timing
See Note 1	Requirements determination	Near
1	Joint/enterprise-wide/MLPS	Near
2	Information management and data standardization and management	Near
3	Sense and respond clinical and medical logistics	Mid
4	Training	Mid
5	Acquisition	Long
6	Joint medical logistics management center	Long
	Automatic identification technology	Near
	Distribution	Near

Table 4-1. Enterprise Integration Group Prioritized Activities List

Priority	Medical logistics technology area	Timing
	Transportation	Mid
	Communications	Mid

Note 1: The need for a modeling/simulation tool does not depend on any particular logistics technology but is an overarching priority linked to the actual technologies in this table. A clinically valid, commercially linked modeling tool will permit improved use of all other technologies in an integrated medical logistics environment.

Other priorities established by the enterprise integration group are as follows:

- Modeling and simulation
  - Clinical event begets medical logistics requirements
  - Commercial medical vendor reaches into the theater
- Research and development resources
  - Joint laboratory for testing and prototyping
  - Testing and information sharing
  - Resource direction and ownership
- Commonality between services
  - Human capital capability
  - Enterprise governing organization
  - Community of interest
- Training
  - Common tactics, techniques, and procedures
  - Learn other service processes and procedures
  - Need for information systems to provide knowledge
- Data standardization
  - Cleansed, accurate master data 99.99 percent of the time

- Master data, including products, suppliers, customers
- Single authoritative source of data shared enterprise-wide.

Asset Management and Asset Visibility

Colonel Roger Olsen summarized the material developed by the asset management and visibility group, which featured four overarching themes that influenced the specific priorities the group established:

- The desirability of a coordinated research program—managed through the TATRC portfolio management process—that focuses on logistics technologies (assuming the IRT process of the last 3 days continues as a means of examining and evaluating emerging technologies).
- The need for continued maturation of the MLPS as the "board of directors" for joint military medical logistics.
- The need to greatly improve the process and automation support used to predict the military's wartime medical logistics requirements.
- The need to improve training, including training that prepares medical logisticians to use many of the advanced logistics technologies discussed as future possibilities during this IRT.

The group considered these functional needs and shaped the priorities for medical logistics research:

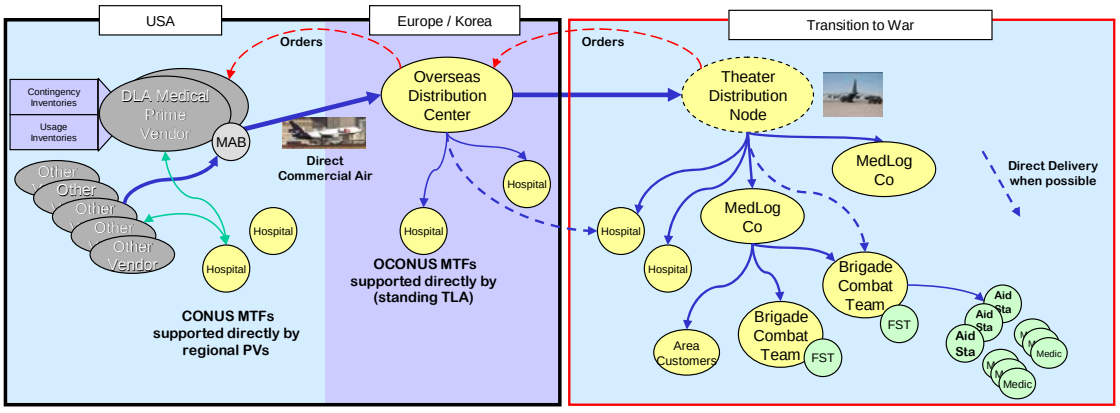
- The short-term research priorities (1–2 years) include modeling for materiel and equipment requirements and training for medical logisticians; "close-in" asset management and visibility tools, including RFID and two-dimensional automatic identification tools; assessment and possible acquisition of COTS systems as candidates for integration into the enterprise; and a continuation of the IRT process or a similar process for IRT-like discussion and collaboration with vendors, academia, and other entities.
- The mid-term research priorities (2–4 years) include continued maturation of a materiel and equipment modeling capability, including integration of modeling tools within the enterprise architecture now being developed for the medical logistics domain; implementation of a comprehensive RFID strategy and the more robust systems and communications capabilities needed to support the strategy; and ongoing assessments of the storage, handling, and transportation characteristics of medical products to simplify or streamline battlefield medical logistics. The group also agreed that expanded partnership with other federal medical agencies such as the CDC, the Federal Emergency Management Agency, and the Department of Homeland Security were likely mid-term targets.

- The long-term research priorities (3–5 years) include full maturation of modeling tools integrated into the production forecasting and planning portions of a future DMLSS system; full integration of automated ID technologies within the medical logistics enterprise; and the acquisition of selected medical products tailored or designed specifically for austere, dynamic, and frequently harsh military environments. Long-term efforts should also be targeted at a fully joint architecture, with business processes, communications channels, and information systems that permit broad, multi-functional partnerships with other federal, state, or international organizations.

Supply Chain Management

Colonel Perry Cooper reviewed the work done by the supply chain management focus group, presenting an Excel-based "capabilities matrix" summarizing desired capabilities, obstacles, and potential strategies. Figure 4-1 shows the graphic COL Cooper also used as an overview of the military medical supply chain, its attributes, and its functional characteristics.

Figure 4-1. Medical Supply Chain Overview



Characteristics of Commodity

- Commercial, non-standard products; no common ID
- DLA/EA business framework provides Services direct access to industry sources; no traditional wholesale level
- High volume, but usually low weight and cube (doesn't fill planes)
- No single market source (pharmaceutical, medical surgical, dental, laboratory, x-ray products)
- Requirements difficult to predict vary with mission, clinicians, and Services
- Potency dating & special handling requirements
- Expensive
- Affected by rapid changes in technology and clinical practice
- *Critical to outcome of patient / casualty care*

OIF Lessons Learned

- Medical Logistics units arrived too late into the theater
- Processes are inadequate for planning / anticipating CL VIII requirements, especially for forward positioning of materiel for initial sustainment
  - Medical Sets are poor predictor of demands
- There is no process to identify individual requirements for prescription medications for AD, RC, DAC and Contractors
- Distribution capabilities did not meet customer requirements, expectations
  - Order-ship time, cold chain capabilities, In-transit visibility
  - Medical supplies frequently delayed at trans-shipment nodes
- Medical units did not have adequate communications necessary for line item ordering of medical supplies
- Many medical logisticians (and leaders) were not adequately trained and experienced to use medical logistics systems & processes
- Metrics were not available to monitor end-to-end performance

The supply chain management's work focused on an assessment of present-day barriers to logistics improvements; desired outcomes; and the capability needed to surmount barriers and achieve desired outcomes. Table 4-2 summarizes the group's presentation.

Table 4-2. Technology Priorities for Supply Chain Management

Desired outcomes (all below)	Barrier (resources and dollars)	Capability	Priority
Medical Supply chain "intelligence ♦ Host nation sources ♦ Customs issues/ logistics infrastructure	FDA clearance; knowing customs requirements	Regulatory relief/review; having intelligence on equivalent or substitutable products	Long term
In-transit visibility from one source/system	Lack of Enterprise Architecture or System (accessibility of authorative, single-source, real-time data)	Med Log ERP down to the customer w/use of forecasting tools	Short
Communication to market, supply chain management (SCM) and from customers	Lack of Data Sync; Lack of Bandwidth/Communication Infrastructure	Med Log ERP down to the customer w/one source of data	Short
Transportation planning—match priorities to capacity	Common Requirements Modeling; Lack of ERP		
Right item/right place/ right time			
Reduced log burden at forward end of SC	Decrease in log resources (staff); no training as we fight	Med Log ERP down to the customer; Smart Shelving and Intelligence Shelving w/usage pattern recognition capability; Virtual Log Environment; "Mobile Engine" using enterprise portal to simplify forward logistics functions	
Minimum investment in inventory consistent with acceptable risk	No single requirements tool	Med Log ERP down to the customer w/use of forecasting tools	
Adopt technologies that reduce complexity or strain on the SC ♦ Digital Imaging ♦ O2 Generation ♦ Sterile or Pure H2O Generation ♦ Power Generation	Dollars; regulatory approval; market place; technical barriers; bureaucracy of cycle		

Table 4-2. Technology Priorities for Supply Chain Management

Desired outcomes (all below)	Barrier (resources and dollars)	Capability	Priority
Simplified ordering and receiving	Decrease in log resources (staff); no training as we fight	Med Log ERP down to the customer; smart shelving and intelligence shelving with usage pattern recognition capability; Virtual Log Environment and RFID; "mobile engine" computers with simplified "Amazon.com"-like enterprise portal	
Minimum # of nodes/Hands-on	Lack of SC planning tools; lack of training; lack of ERP; linear process	Med Log ERP down to the customer	
Containerization that facilities receiving and maintaining	Lack of training; lack of planning; lack of systems to pack items	Med Log ERP down to the customer with use of forecasting tools (moving planning?) with smart shelving	
Flexible and adaptive planning ♦ anticipate vs. react to requirements ♦ interactive with transportation	Lack of single requirements determination and SCM/ERP tool; lack of interface with the transportation system; organizational barrier between tactical units and CONUS organizations	Med Log ERP with condition code requirements linked (from DMSB); requirements generation tool for mission changes such as enemy prisoners of war and pediatric patients	
Visibility of SC performance	Lack of enterprise architecture or system (accessibility of authorative, single-source, real-time data)	Med Log ERP down to the customer	
Need to get better Med Log footprint in theatre in time and need advocacy to support this	Inflexible movement planning system	Better representation at COCOM level w/integrated MedLog planning synced w/industrial base	
Med Log is accessible to customers ♦ Point of contact/ communications ♦ Training	Lack of training	More training	
Short customer wait time	Lack of quality info	Med Log ERP down to the customer with predictable modeling tool	
Lean supply chain ♦ Fewer people ♦ Minimum inventories	Lack of Vertical Integration of SCM activities; Lack of Confidence in communications and responsiveness	Reliable communications	
No product loss due to environment	Lack of training; lack of asset visibility; lack of technologies w/o environmental requirements	Investment in technology to develop material that does not require temp sensitive consumables/equipment; ERP	

Table 4-2. Technology Priorities for Supply Chain Management

Desired outcomes (all below)	Barrier (resources and dollars)	Capability	Priority
Clinicians have confidence in SC	Lack of training; lack of responsiveness and visibility; performance metrics		
Speedy information for: ♦ Order/requirements visibility ♦ Product equivalents ♦ Frustrated cargo ♦ Receipted cargo	Lack of enterprise architecture or system (accessibility of authorative, single-source, real-time data); lack of communications for intransit visibility; lack of training; lack of intransit visibility	Med Log ERP down to the customer with use of forecasting tools and Smart Shelving and RFID and automated flags highlighting transportation issues	
Order generation that does not require human intervention	Money/research/availability/link to a central system	Smart shelving and intelligence shelving with usage pattern recognition capability	

The Supply Chain Management group carried its work one step further than the above list of mostly unprioritized technology needs. The group refined the list to produce Table 4-3, a consolidated list of needed capabilities. This list represents a "distillation" of the technologies listed in Table 4-2, and represents the high-level priorities for improved technology support to an integrated, global medical logistics supply chain with both commercial and military nodes.

Table 4-3. Consolidated List of Capabilities

Technology needed	Priority
Basic functionality of ERP	Short term
with enhanced capability of smart shelving/POU	Short term
with RFID links and intransit visibility	Intermediate
with forecasting tools	Intermediate
Better rep at COCOM level w/integrated Med Log planning synced w/ industrial base	Short term
Better training of logisticians and clinical end-users	Short term
Reliable communications	Intermediate
Reliable transportation	Long term
Cold chain technologies (containerization and monitoring)	Short term
Reduced reliance on products needing specialized cold chain management	Intermediate

Materials, Energy, Transport, and Environment

Colonel Bill Fry summarized the work produced by the materials, energy, transport, and environment group. He highlighted the need for

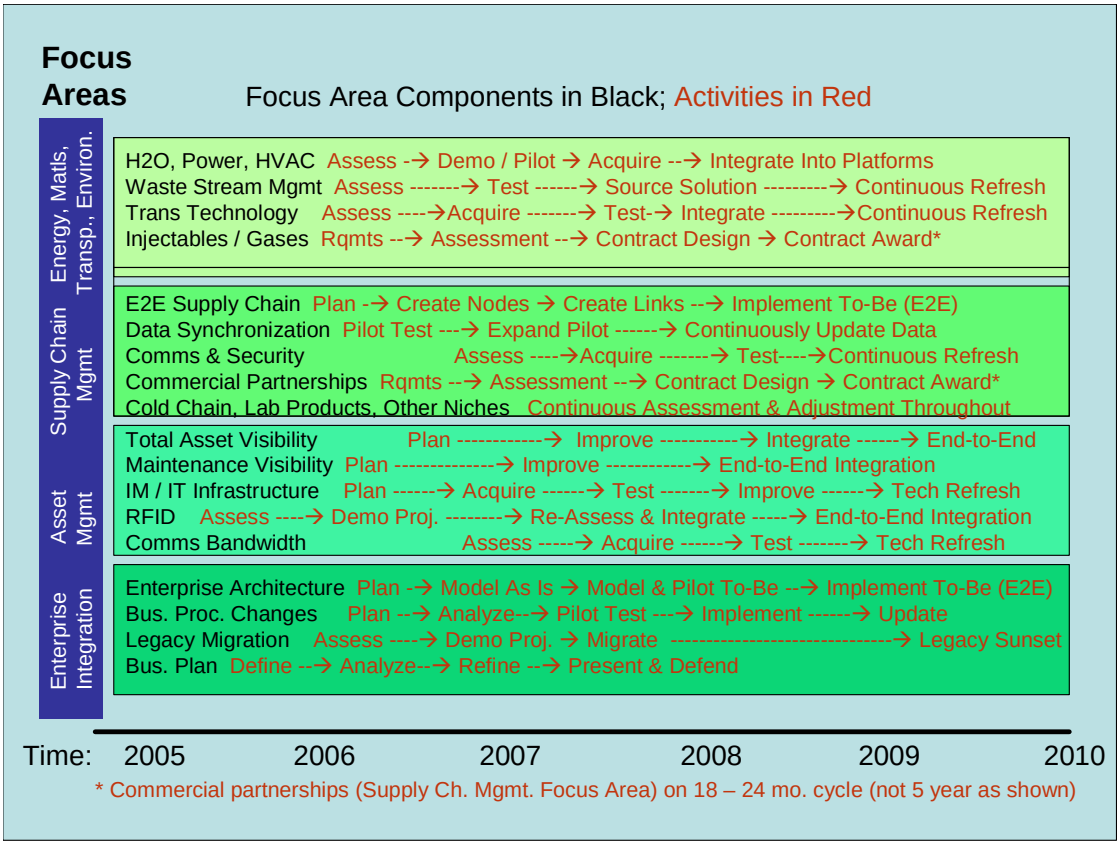
- improved, fully integrated IM/IT solutions to support medical logistics processes;
- adaptive, clinically driven tools to produce more realistic, more supportable requirements estimates of wartime medical materiel needs; and
- greatly improved communications capability, including broadband and satellite capability, for connectivity within a theater of operations and between the theater and the infrastructure supporting the theater.

He also summarized the need for ongoing research into opportunities for improving the processes of water and gas production; waste stream management; cold chain management (including real time, continuous cold chain monitoring); reduction of special handling needs for medical materiel; and elimination or extension of potency-dated products. The group also focused on short-, mid-, and long-term time horizons to identify and assess opportunities in the short term; design and conduct demonstrations or pilot projects in the mid-term; and acquire actual solutions in the long term. He noted that the processes now used by the services to estimate wartime requirements need to be modernized and distilled into a single, joint requirements estimation process in the short term. As a mid-term goal, products specified in the joint requirements estimation process should be studied to determine which of those requiring special handling can be eliminated or substituted for with other products more easily shipped and stored.

CONSOLIDATED MEDICAL LOGISTICS TECHNOLOGY ROADMAP

Following the workgroup presentations, we designed a draft consolidated medical logistics technology roadmap (Figure 4-2). The roadmap, as now constructed, does not incorporate resource requirements, but does reflect the relative priority and schedule estimates provided by each workgroup. Resource requirement estimates—developed in collaboration with industry, academia, and military IRT participants—are likely the next step in the IRT process. Workgroup leaders and members are encouraged to submit comments or new concepts for display of the roadmap (included with the e-mail used to distribute the draft proceedings).

Figure 4-2. TATRC Medical Logistics Technology Roadmap (Draft)



Several broad themes emerge from a broad-spectrum, cross-workgroup review of the workgroup products. The following points summarize those themes:

- Under the sponsorship of the DMLSS Program Office, acquire and implement an enterprise wide information system with a service-oriented architecture, authoritative enterprise-level master data, and re-engineered business processes based on enterprise-centric rather than MTF-centric functions. The enterprise strategy should include the attributes defined by the IRT and should provide greatly simplified and transparent logistics management tools for far-forward support to clinicians, soldiers, and others without specialized logistics training.

- Determine feasibility and if feasible develop a real time/near real time Class VIII modeling tool to estimate/predict requirements based on actual/anticipated patient conditions. There is unanimous agreement that the current process is inadequate, but progress toward a solution is not apparent. Early prototypes, including the Joint Medical Materiel Modeling Tool (JM3T) and the Estimating Supplies Program (ESP), should be evaluated for their future utility; other efforts, such as the Common User Database, may also have potential, but will require integration within the future medical logistics architecture. Modeling and forecasting tools, if acquired,

could have public health/emergency response potential as well. Until an improved forecasting model is available, medical logisticians will continue to overburden the supply chain and sub-optimize overall supply responsiveness, especially in the early days of an operation before the supply chain matures.

- Monitor the evolution of RFID and other automatic identification technologies with relevance to the medical commodity. Look for ways to partner with other Federal agencies and the private sector to enhance development and leverage the technology for specific applications like in-transit visibility and cold chain management. Develop an automatic ID technology investment strategy for DoD and the military services.

- Monitor, foster, or sponsor R&D for technologies with potential to significantly improve power, water, and medical gas generation, distribution, and storage requirements. Many of the initiatives discussed during the IRT have the potential to transform DoD's medical logistics system dramatically.

- Assess the changing nature of medical products used on the battlefield (and for other contingency operations) and determine emerging technologies and business practice changes that will enhance the handling and management of these items while in the supply chain. Cold chain management, waste stream management, power consumption, and transportability requirements might all be reduced, simplified, or eliminated if re-engineered medical products can be developed, acquired, or substituted. The medical logistics community must keep pace with changing nature of medical products, but opportunities may exist through the R&D process to drive changes in battlefield-critical medical products.

- Partner with other federal agencies (e.g., the CDC's Strategic National Stockpile program) and develop a stability testing program for items commonly stockpiled or potentially stored for long periods of time outside recommended storage conditions. DoD has done stability testing on selected products but there are more where understanding the limits before efficacy is impacted.

The workgroup products were next consolidated to produce the integrated "roadmap" displayed above. This roadmap represents a synthesis of the priorities, technological maturity, resource availability, and operational needs of the medical logistics community. It therefore reflects an overall direction for the logistics research and development efforts supporting the military health system. If the roadmap is used as planned, it will also ensure an effective governance mechanism by which the medical logistics senior leadership can charter, oversee, and assess research efforts over time.

SEMINAR CONCLUSION

The 3-day 2005 medical logistics technology IRT seminar concluded on Wednesday, May 16, at 1600 hours. Closing comments from Rich Ursone, John DePasquale, and Jim Olson touched on the immense progress made in describing, assessing, and prioritizing the many technologies, business processes, and organizational activities involved in the seminar; the hard work and spirit of cooperation in evidence throughout; and the enormous opportunity represented in the IRT effort. Future activities will be coordinated among the IRT participants, and the participants agreed upon (but did not finalize) plans for a subsequent seminar.

Several important activities were specified or implied as follow-on actions to the IRT.

The relationship between TATRC and the DMLSS program should be formalized. TATRC is now accepted as the research and development "arm" of the DMLSS program, and should pursue future research opportunities consistent with the overall strategic direction of DMLSS and the military medical logistics enterprise. The overall architecture of the enterprise will be guided by the DMLSS program and the Medical Logistics Proponent Subcommittee governing it, and TATRC initiatives will be compliant with their standards, protocols, business objectives, and strategic intent. Obviously, R&D efforts are by definition on the "leading edge" and may not initially comply with the existing architecture, but integrating them within an architectural framework will be a necessary precursor to their broad acceptance and use in the enterprise. Specific governance documents, such as the MLPS charter, may need revision to accomplish the linkage of TATRC R&D efforts with other medical logistics initiatives.

There is, and will continue to be, ambiguity and fluctuation in the funding outlook for medical logistics R&D efforts. These ambiguities can be best accommodated by a well-constructed, internally consistent R&D strategy formulated as a component of the overall medical logistics policy. In the broad context, medical logistics policy will govern the overall enterprise architecture and its business practices, guide the acquisition of information systems, shape medical logistics doctrine, and establish priorities and performance expectations for TATRC's medical logistics R&D efforts.

The medical logistics IRT surpassed expectations and provided a broad, strategic azimuth for all participants to aim toward. Future efforts, including subsequent IRT meetings, will be needed to achieve the goals outlined in this session. IRT participants are deservedly proud of the event, which is a milestone in the maturation of both TATRC and the military medical logistics community it supports.

Appendix A
Seminar Agenda

Figure A-1 shows the times, topics, and presenters for the presentations made at the 3-day IRT seminar.

Table A-1. Seminar Agenda

TIME	TOPIC	PRESENTER
	Day 1 - Monday, 16 May 2005	
0730 - 0800	Continental Breakfast, Check-In, and Registration	All Participants
0800 – 0825	Opening Remarks and Welcome Charge to Participants, IRT Overview and Rules of Engagement	Mr. James Olson, bio Mr. John DePasquale, bio Mr. Conrad Clyburn, bio
0825 - 0830	Greeting and Administrative Remarks	Ms. Lori DeBernardis
0830 – 0845	Comments from The Acting Commander	COL. James A. Romano, Jr., Ph.D. Bio
0845 - 0900	The Integrated Research Team Process: A Madness to the Method: A Charge to the Participants	Kenneth Curley, M.D. Bio
0900 – 0915	Conference Focus Areas	Mr. Roger Miller Bio
0915 - 0930	**Mid-Morning Break**	
0930 - 1000	Medical Logistics Overview: Yesterday, Today, and Tomorrow: Why We Care	BG (Ret) Richard Ursone Bio Abstract
1000 – 1030	Joint Enterprise Wide Logistics – Medical	Mr. George Hammel Bio Abstract
1030 – 1110	Lessons from Distribution Process Improvement for the Army	John Halliday, Ph.D. Bio Abstract
1110 – 1150	Achieving Supply Chain Visibility	Ms. Ann Grackin, CEO Bio Abstract
1150 - 1300	**Buffet Style Lunch**	All Participants

TIME	TOPIC	PRESENTER
1315 – 1355	Introduction to the Supply Chain 2020 Project	Larry Lapide, Ph.D., Bio Abstract
1355 – 1435	Future Trends in Logistics Technology	COL William Fry Bio
1435 - 1455	**Mid-Afternoon Break**	All Participants
1455 – 1525	Mobile Computing/BMIST	Mr. Tommy Morris bio
1525 – 1555	Robotics/MEMS/NANO Research	Gary Gilbert, Ph.D Bio Abstract
1555– 1610	Ground Rules for Breakout Groups	Mr. Roger Miller Bio
1610– 1710	Breakout Groups Separate: Finding and Exploiting Integration Opportunities	All Attendees Participate
1710 – 1730	Breakout Groups Call to Order, Recap	Mr. Roger Miller Bio
1730	**Adjournment of Day One**	
	Day 2 - Tuesday, 17 May 2005	
0730 – 0800	Continental Breakfast, Check-In, and Registration	All Participants
0800 – 0830	Overview of the Department of Defense Medical Logistics System in 2005	COL Don Buchwald Bio Abstract
0830 – 0930	Supply Chain Excellence A short primer on Dell's practices	Mr. Mike Gray Bio
0930 – 0945	**Mid-morning Break**	All Participants
	Asset Management / Visibility	
0945 – 1015	Department of Defense RFID Initiative	Mr. Paul Donato Bio
1015 – 1100	Emerging RFID Applications: "Improving Patient Safety with RFID"	In Mun, Ph.D. Bio Abstract Mr. Dan Neuwirth, Bio
1100 – 1130	The Evolution of Alien RFID	Mr. Mark McDonald Bio Abstract
	Supply Chain Management	
1130 – 1200	Emerging Complexity in Supply Chain Management: A Platform for Technological Change	Oliver Hedgepeth, Ph.D., Bio Abstract

TIME	TOPIC	PRESENTER
1200 – 1300	**Buffet Style Lunch**	All Participants
1315 – 1345	Point-of-Use Integration Opportunities	Mr. Ralph Cadwallader Bio Abstract
1345 – 1415	Cold Chain an Introduction	Ms. Carla Reed Bio
1415 – 1445	Advances in Miniaturization	Randy S. Haluck, M.D. Bio
	Energy, Materials and the Environment	
1445 – 1515	Advances in Energy Research	Mr. David Scharett Bio
1515 – 1530	**Mid-Afternoon Break**	All Participants
1530 – 1600	Advances in Waste Stream Management	James Garvey, Ph.D. Bio Abstract
1600 - 1630	Advances in Oxygen and Water Production	Tarik Naheiri, MS., ChE., Bio Abstract
1630 – 1700	Environmental Control in a Medical Environment	Thomas Hughes, Ph.D., Bio
1700 - 1800	**Breakout Groups Separate: Exploiting Opportunities and Forming Partnerships** Red Group: Focus Area/Topic to be determined Facilitator: COL Roger Olsen Green Group: Focus Area/Topic to be determined Facilitator: BG (Ret) Richard Ursone Blue Group: Focus Area/Topic to be determined Facilitator: Col Perry Cooper Blue Group: Focus Area/Topic to be determined Facilitator: CAPT Shari Kirshner	
1800 - 1815	Breakout Groups Call to Order, Recap	All Attendees Participate
1815	**Adjournment of Day Two**	
	Day 3 - Wednesday, 18 May 2005	
0730 - 0800	Continental Breakfast	All Participants
0800 – 0830	Rules of Engagement and Charge to Breakout Groups	Mr. Roger Miller Bio Ms. Susan Purdum Bio

TIME	TOPIC	PRESENTER
0830 - 1130	**Breakout Groups Separate: Exploiting Opportunities and Forming Partnerships** Red Group: Focus Area/Topic to be determined Facilitator: COL Roger Olsen Green Group: Focus Area/Topic to be determined Facilitator: BG (Ret) Richard Ursone Blue Group: Focus Area/Topic to be determined Facilitator: Col Perry Cooper Blue Group: Focus Area/Topic to be determined Facilitator: CAPT Shari Kirshner	
1000– 1015	**Mid-Morning Break**	All Participants
1130 - 1300	**Buffet Style Lunch**	All Participants
1300 - 1400	Groups Re-Form/ Group Leaders report to all participants	Group Leaders
1400 – 1600	Group Leaders meet with Government Representatives	Group Leaders
1600	**Meeting Adjournment**	All Participants

Appendix B
List of Presenters

Table B-1 lists the presenters featured at the 3-day IRT seminar

Table B-1. Seminar Presenters

COL Donald Buchwald
U.S. Army, Director, Defense Supply Center, Philadelphia's Directorate of Medical Materiel

Mr. Ralph Cadwallader
Material Services Consultant, Cardinal Health Care/Pyxis

Kenneth Curley, M.D., Ph.D
Chief Scientist,
Telemedicine and Advanced Technology Research Center (TATRC)

Mr. John DePasquale
Project Manager, Telemedicine and Advanced Technology Research Center (TATRC)

COL William Fry
Commander,
United States Army Medical Materiel Agency (USAMMA)

James Garvey, Ph.D.
Professor, State University of New York, (SUNY) Buffalo

Gary Gilbert, Ph.D.,
Chief, Knowledge Engineering Group, Telemedicine and Advanced Technology Research Center (TATRC)

Ms. Ann Grackin, CEO
ChainLink Research

Oliver Hedgepeth, Ph.D.
Assistant Professor, Chair,
Logistics Department University of Alaska, Anchorage

Thomas Hughes, Ph.D.,
Assistant Director, Energy Science and Power Systems Division,
Pennsylvania State University

Larry Lapide, Ph.D.
Research Director, Massachusetts Institute of Technology Center for Transportation and Logistics

Mr. Mark McDonald
Director, Program Management
Alien Technologies

Mr. Tommy Morris
Chief Information Technology Officer
Director, Mobile Computing
Telemedicine and Advanced Technology Research Center (TATRC)

In Mun, Ph.D.
Director of Hospital Research,
Massachusetts Institute of Technology

Tarik Naheiri, MS., ChE.
Director, Pacific Consolidated Industries, LLC

Ms. Carla Reed
Vice President, Global Logistics and Distribution ChainLink Research

Table B-1. Seminar Presenters

Mr. Mike Gray
Supply Chain Evangelist, Dell Inc.

John Halliday, Ph.D.,
Project Leader, Rand Corporation

Randy S. Haluck, M.D.
Associate Professor,
Pennsylvania State University,
Hershey Medical Center

Mr. George Hammel
Senior Analyst, Defense Medical
Logistics Standard Support (DMLSS)

COL. James A. Romano, Jr., Ph.D.
Acting Commander
U.S. Army Medical Research and
Materiel Command (USAMRMC)

Mr. David Scharett
Senior Research Scientist Pacific
Northwest National Laboratory

Appendix C
Letter of Intent

This appendix discusses the purpose, mission and objectives, and outcomes expected of the IRT seminar.

PURPOSE

We are at an interesting juncture in the art and science of (medical) logistics. New technologies and business practices are emerging with the promise of reducing or eliminating the complexity that's associated with the practice of logistics, especially when logistics is practiced in the battlespace. Many research questions exist with respect to Automated Identification Technologies (AIT), logistics business practices, enterprise systems, functionality, and integration into the medical logistics process. By addressing these and other related issues, IRT participants will work with TATRC to develop a strategy for creating a medical research and development portfolio dedicated to advancing the practice of medical logistics via conceptualization and execution of state-of-the-art prototype devices that are modular in concept and multifunctional/multi-procedural in capability for implementation across the spectrum of care within DoD, from the battlefield to its Tertiary Care Centers. As is often the case, this effort will drive the continued development of these technologies in the civilian sector as well.

Our focus in this IRT will be on four broad areas of technology: enterprise-wide integration technologies; asset management and visibility technologies; supply management; and energy, materials, and the environment. The roadmap that we will construct will follow a 5-year timeline. By focusing on a range of potentially transformational technologies to be applied to the core logistics systems and processes used to support operational medicine, we will determine what can be accomplished in the short (1–2 years), intermediate (3–4 years), and long terms (5 years and beyond).

MISSION AND OBJECTIVES

The mission of this IRT is to develop a 5-year research and development roadmap, to include estimates of funding requirements. The 5-year period is intended as a starting point for R&D versus a delivery point of a product. The objectives are based upon areas of need in military medicine and the participants are challenged to identify existing or emerging supporting technologies that can be applied to those needs.

The areas and objectives include the following:

- Enterprise-wide integration and the “unbounded”
  - Collaboration throughout the logistics network
  - Enterprise resiliency and security
  - Enterprise responsiveness and flexibility
  - Interconnectivity across the Services
  - Interconnectivity with USTRANSCOM, intergovernmental agencies, and other enterprises
- Asset management and visibility
  - Application of enabling technologies for asset management
    - RFID
    - Wireless handhelds
    - Global positioning system
  - Sense and respond logistics for asset diagnostics and prognostics
  - Transportation capacity and choke points
  - Distribution capacity and choke points
  - Processes and applications at ports of debarkation and embarkation
  - Clinical user interface
- Supply management
  - End-to-end supply chain visibility
  - Application of enabling technologies for supply management
  - Supply segmentation and criticalities
  - Transportation utilization, capacity, and choke points
  - Distribution utilization, capacity, and choke points
  - Processes and applications at ports of debarkation and embarkation

- Energy, materials, transport, and the environment
  - Smart containers
  - Cold chain
  - Containerization
  - Miniaturization
  - Waste management
  - Environmental control of the clinic
  - New energy sources and uses.

Four working groups will be formed to address these topic areas. During Days One and Two, all four groups will have the opportunity to discuss each main topic area and will be tasked with identifying and prioritizing the key issues and opportunities in each area. On Day Three, each working group will be assigned a specific topic area and will further explore the issues and opportunities identified for this topic area to develop a roadmap for future consideration by TATRC. The groups will consider their topic with respect to short- (1 year), mid- (2–4 years) and long-term (5+ years) feasibility. Goals in each period should be stratified from most to least important or feasible if possible, developing a matrix of what goals can be accomplished in each time period along with estimates of research funding required to achieve the goals.

EXPECTED OUTCOMES

At the conclusion of the work groups, the group leaders will present the group findings to the entire IRT audience. The group leaders will then meet with the IRT government team and other government experts to synthesize a single roadmap from the group roadmaps. A draft R&D roadmap with estimates of funding requirements will be the outcome of the IRT. After the IRT, group leaders will work with the government IRT team to produce group reports and an overall report suitable for publication. These reports will be used by TATRC to inform local command and collaborating agency leadership, as well as other interested government parties of R&D needs in this arena.

Appendix D
Welcome Message

This appendix contains the welcome message from the chairmen of the IRT seminar.

On behalf of Col Jeffrey Roller, Director, Telemedicine and Advanced Technology Research Center (TATRC), we would like to welcome you to the Integrated Research Team (IRT) on "Medical Logistics: Exploiting Emerging Technologies." An IRT is a formal process of strategic planning for research and development and the investment of research dollars. Our Medical Logistics IRT includes DoD participants with interests in the full spectrum of medical logistics and researchers and developers from academia and industry. TATRC has used the IRT process to good advantage for recommendations for research direction and the management of funds for our Medical Simulation, Imaging, Operating Room of the Future (ORF), Surgical Robotics, and Bio-Medical Nanoscience research portfolios.

We are at an interesting juncture in the art and science of (medical) logistics. New technologies and business practices are emerging that bring with them the promise of reducing or eliminating most or all of the chaos and waste that are sometimes a part of the practice of logistics, especially when logistics is practiced in the battlespace. Many research questions exist with respect to Automated Identification Technologies (AIT), logistics business practices, enterprise systems, functionality, and integration into the medical logistics process. By addressing these and other related issues, IRT participants will work with TATRC to develop a strategy for creating a medical research and development portfolio dedicated to advancing the practice of medical logistics via conceptualization and execution of state-of-the-art prototype devices that are modular in concept and multifunctional/multi-procedural in capability for implementation across the spectrum of care within DoD, from the battlefield to its Tertiary Care Centers. As is often the case, this effort will drive the continued development of these technologies in the civilian sector as well.

As one looks around the room, one might ask, "Why is that person here" or "Why isn't someone else here?" The roster of our attendees does not intend to exhaust every area of expertise related to medical logistics. Unfortunately, not everyone we invited was able to attend. We have sought representation from various groups sufficient to allow intelligent deliberation of medical logistics issues in order to develop a research and development roadmap and investment strategy that we can use for management purposes and that we can present to our leadership in order to engender their support. Also, we have learned through our experiences that size does matter: while the optimal group size is 65–70 participants, and workgroups are about 15 members, we are working with much larger numbers in this instance, with the hope that the IRT will not suffer.

The format of the IRT has changed over the years to allow continued application of lessons learned. The present IRT will begin with presentations for most of the first 2-days by DoD, industry, and academic participants who will describe the current state of the field, including strengths and weaknesses and will provide a view to the future. The final hour of the first two afternoons will be spent by the workgroups capturing the highlights of that day, and beginning to formulate the focus and direction of their portion of the roadmap. The roadmap that we will

construct will follow a five year timeline. Participants should consider what is presented in the context of this timeline and more specifically, should begin to determine what can be accomplished in the short (1–2 years), intermediate (3–4 years), and long terms (5+ years). The third morning will be dedicated to the workgroups, where they will finalize their specific topic areas and will address them in the above context. Following lunch on the final afternoon, the group leaders will report their findings to the entire body. Finally the group leaders will meet with government representatives to formulate the roadmap and the final IRT report.

We would like to express our sincerest appreciation to LTC Stephen Downs, of the Defense Supply Center, Philadelphia (DSCP) and COL Don Buchwald, DSCP Director of Medical Materiel, for providing substantial financial support for this undertaking. Additionally, we would like to thank the Penn State University Center for Supply Chain Research, especially Ms. Susan Purdum, for all of the effort spent on organizing this very challenging program. Special thanks also goes to Mr. Daniel Blum, Mr. James Canella, and Mr. Roger Miller for all the wisdom and expertise they afforded us and time and effort they spent dealing with the chairmen. And finally we'd like to thank our internal conference planning team, without the support and efforts of Ms. Lori DeBernardis, Ms. Tina Mathews, and Mr. Andrew Broadhust, the outcome of this conference would not be possible...

And finally, thanks to each one of you, for without your attendance and participation, the mission of our medical logistics IRT could not be accomplished.

We wish you all a productive and rewarding IRT, and believe that you will depart having accomplished a great deal, in addition to the development of a feasible R&D roadmap.

Thank You,
Mr. C. James Olson
Mr. John DePasquale

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
08-2005	Final	

4. TITLE AND SUBTITLE
Telemedicine and Advanced Technology Research Center Medical Logistics Integrated Research Team
Seminar Proceedings, May 16–18, 2005

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Not applicable

5d. PROJECT NUMBER

5e. TASK NUMBER
AR514T1

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

LMI
2000 Corporate Ridge
McLean, VA 22102-7805

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Patricia A. Evans
Telemedicine and Advanced Technology Research Center
820 Chandler Street
Fort Detrick, MD 21702-5014

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
A: Approved for Public release. Distribute to DTIC and defense libraries, NTIS, or other appropriate government report databases.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The Army Telemedicine and Advanced Technology Research Center, a subordinate of the U.S. Army Medical Research and Materiel Command, sponsored a Medical Logistics Technology Integrated Research Team (IRT) meeting in Frederick, Maryland, on May 16–18, 2005. The IRT brought together academic, commercial, and government technology experts to focus on logistics technologies, devices, and business processes of potential relevance to military medical logistics, with an emphasis on warfighter support needs, current operational experience, and emerging technologies. The IRT was steered by Army, Navy, and Air Force medical logistics leaders and produced as its output a "medical logistics technology roadmap" that established short-, mid-, and long-term priorities for continued research, development, and implementation to support the military health system and the warfighters who depend on it. High-level priorities included the acquisition of an enterprise-level information system to support the worldwide medical logistics function; the acquisition of accurate, patient-driven requirements modeling and simulation tools; the assessment and possible acquisition of automatic identification technologies to permit precise management of medical products in the global medical supply chain; improved sustainability and reduced logistics complexity for medical products, including medical gases, fluids, fuels, and waste management systems; and improved partnership with other federal, commercial, and academic organizations with research interests in the medical logistics field.

15. SUBJECT TERMS
Medical Technology; Medical Logistics; and Logistics Technology.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	Unclassified Unlimited	62	Nancy E. Handy
					19b. TELEPHONE NUMBER *(include area code)* 703-917-7249

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